INSTRUCTION BOOK

FREQUENCY UNIVERTER
TYPE CA-207-A

Maufactured for

UNITED STATES DEPARTMENT OF COMMERCE
CIVIL AERONAUTICS ADMINISTRATION

CONTRACT Cca-29175

Order Nos. CA-51-3738 Dated: April 17, 1951
CA-51-3853 Dated: June 18, 1951

Manufactured by

BOONTON RADIO CORPORATION
Intervale Road, Boonton, New Jersey

NOTE

The 207-A Univerter referred to within the text is identical electrically and physically with Type CA-207-A Frequency Univerter and, accordingly, this instruction manual is applicable for use with either instrument type.

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TYPE 207-A UNIVERTER

I. INTRODUCTION.

The Type 207-A Univerter, a frequency converting accessory of unity gain, is designed for use with the Types 202-B and 202-C FM-AM Signal Generators to provide additional frequency coverage of 0.1 mc. to 55 mc. Since the 202-B and 202-C FM-AM Signal Generators cover a frequency range from 54 to 216 megacycles, the 207-A offers a simple and convenient means whereby the additional coverage of commonly used intermediate and radio frequencies may be obtained. This instrument also makes available at these lower frequencies the frequency and amplitude modulation features and the attenuator calibration of the 202 instruments, without adding any appreciable distortion.

Physically, the Univerter consists of a front panel assembly, RF chassis, and regulated power supply. The power supply chassis is secured to the rear panel of the equipment cabinet, while connections to the RF

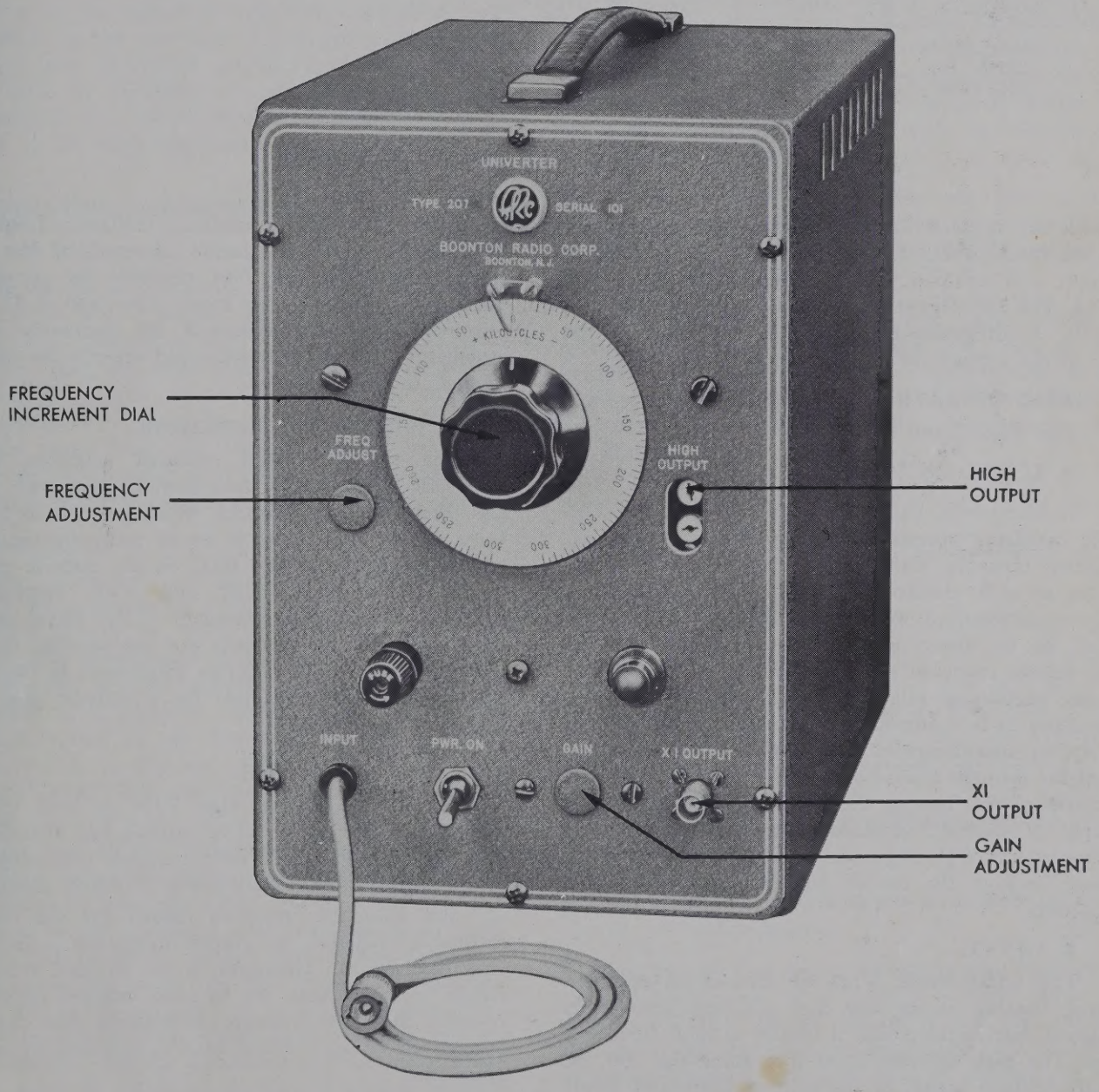


Fig. 1. Front View of 207-A Univerter

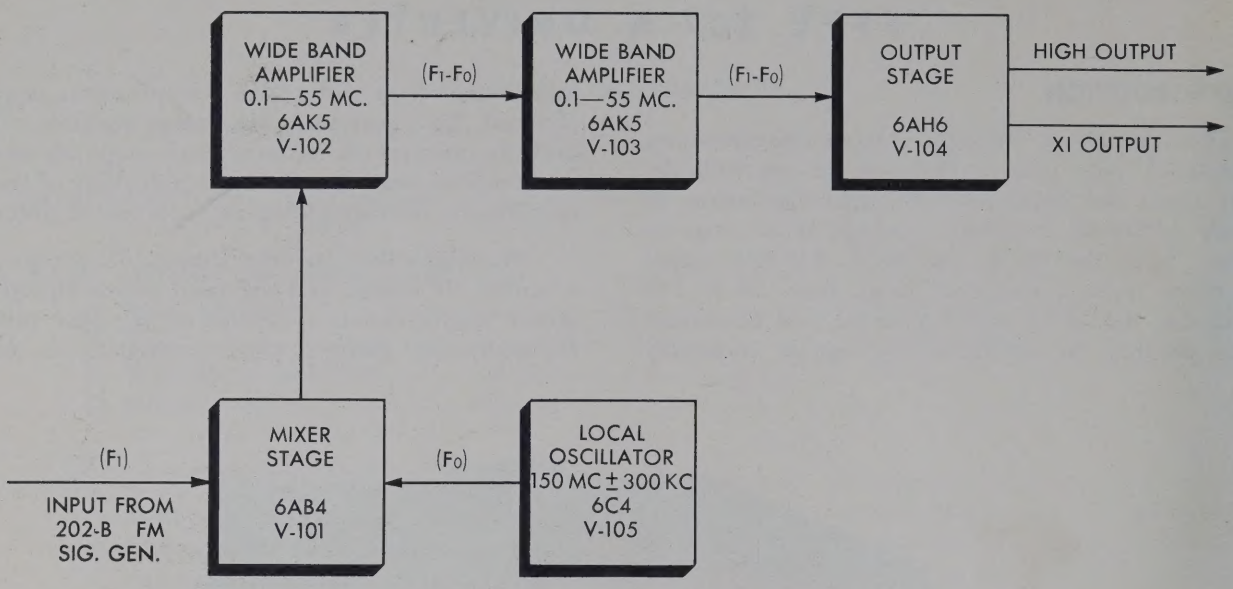


Fig. 2. Basic Elements of 207-A Univerter

chassis are made with a cable and plug arrangement on the front panel. The entire assembly is both lightweight and compact, matching the type 202-B and 202-C FM-AM Signal Generators in proportions and finish. A collapsible leather handle is attached to the top of the cabinet for convenience in carrying.

II. BASIC OPERATING PRINCIPLES.

(See Figs. 2 and 11)

A. LOCAL OSCILLATOR.

A 6C4 triode V105 functions as a modified Colpitts oscillator operating at a frequency of 150 mc. Vernier capacitor C134 permits the 150 mc center frequency to be shifted up or down the frequency spectrum a maximum of 300 kc. The "Frequency Increment Dial" on the front panel of the instrument controls this vernier capacitor and is calibrated in 5 kc. increments, permitting relatively small changes in output frequency to be made such as are required for receiver selectivity measurements. Variable capacitor C137 available through access hole marked "FREQ", provides a means of zero beating the oscillator with the 150 mc output of the 202 generator with which the 207 is associated. A high degree of oscillator stability is obtained through the use of temperature compensating capacitors.

B. MIXER.

The 6AB4 triode V101 as used is an excellent mixer, because of its very high g_m and because its physical characteristics suit it ideally to high frequency use. The pick up coil L110 introduces the 150 mc local oscillator signal to the grid of the 6AB4 triode V101 while the signal from the associated 202 develops a voltage across the cathode resistor R-101. V101 mixes the two signals to produce a difference frequency. The 68-ohm cathode resistor shunted by the tube internal impedance of V101 provides the proper 53 ohm termination for the input cable and a 53 ohm termination for the associated 202 generator whose attenuator dial will therefore read directly the voltage applied to the Univerter.

C. WIDE BAND AMPLIFIER.

The two wide-band cascaded amplifier stages V102 and V103 employ four-terminal, low pass, dead-end filter coupling networks, which pass 0.1 to 55 mc. Gain of the instrument is set to unity by means of potentiometers R128 and R117 in the cathode circuits of the 6AK5 tubes V102 and V103 respectively. Cathode degeneration minimizes Miller effect so that the pass band characteristics are independent of gain control settings. The trimmer condensers in the filter networks are used to adjust for a uniform gain over the entire pass-band.

D. OUTPUT STAGE.

The 6AH6 output stage V104 is both cathode and plate loaded. The plate loading has virtually no effect upon the cathode output circuit indicating that the 6AH6 operates as very nearly a perfect pentode.

The value of resistance chosen for the cathode resistor is such that the output impedance is 53 ohms. The gain of the Univerter is set so that the open circuit voltage across the 53 ohm internal impedance is twice the input voltage. It follows then that the voltage across an external load is obtained by use of ohms law:

$$1.\ Eo = 2E\frac{Z_L}{Z_I + Z_L}$$

Where E_O = 207 output voltage
Where E = 202 attenuator dial reading
Where Z_L = load impedance
Where Z_I = internal impedance

When the external load is 53 ohms the effective gain of the instrument is unity and the attenuator dial of an associated 202 reads the Univerter output directly.

The plate output offers an open circuit gain of 7.5-8 times the input voltage at an internal impedance of approximately 330 ohms. This circuit is factory adjusted for maximum pass band flatness with 10 $\mu\mu$f connected externally to simulate an average external load, which is approximately equivalent to a short length of 300 ohm twin lead plus the input capacitance of a vacuum tube. Although the bandpass as viewed across the cathode is independent of plate load the reverse is not true due to changed degeneration resulting from change in cathode load. Therefore a 501-A cable or equivalent 53 ohm termination must be connected as a cathode load if optimum flatness is desired at the high impedance plate output.

III. OPERATING INSTRUCTIONS.

A. SETUP.

Set up the 207-A Univerter for use as follows: Connect the 501-A output cable (or suitable cable-adapter combination) to the X1 OUTPUT of the Univerter, plug the input coaxial cable of the 207-A into the RF output receptacle of the 202, energize both instruments from any convenient 105-125 volt, 60 cycle power line and allow one hour warm up period before proceeding. (The 207 alone may operate from a 90-130 V, 60 cycle power line.)

B. CHECKS.

The frequency of the Univerter oscillator is checked by zero-beating with a 202 generator. This inspection should be made upon receipt of initial delivery and occasionally thereafter. To perform the check connect a null indicator such as a pair of earphones or a sensitive vacuum tube voltmeter to the high output of the Univerter and set the 202 frequency dial to 150 mc. Remove the plug button marked "FREQ" from the 207 front panel, and adjust variable capacitor C137 for zero beat.

The gain of the Univerter may be measured by comparing its output voltage as read on a vacuum tube voltmeter with the input voltage from the 202, indicated by the attenuator dial. Connect an accurate vacuum tube voltmeter to the X1 OUTPUT with a 501-A cable and shift the 207 oscillator frequency about 100 KC from zero-beat by means of the "Frequency Increment Dial". The reading of the vacuum tube voltmeter and the attenuator may be made equal (unity gain) by adjusting the first amplifier cathode potentiometer R128 (Fig. 4), accessible by removing the plug button marked "GAIN" from the front panel.

C. OPERATING PROCEDURE.

1. *The lower frequency limit* is determined in part by the service desired since the fundamental frequency must be sufficiently removed from the lower pass band limit to avoid side band cutting as follows:

Service	Lower Frequency Limit
CW	100 kc
AM-Modulation —	100 kc + Modulation Frequency
FM-Modulation —	100 kc + Deviation Frequency + Modulation Frequency*

2. *The Frequency Increment Dial* is useful in providing small frequency changes, in increments of 5 KC to a total of +300 KC. This feature is convenient when measuring pass band characteristics of amplifying systems. Where the greatest degree of accuracy is desired, the frequencies involved should be approached with the same direction of rotation to minimize the effects of backlash.

3. *The method of connecting the load* to the Univerter must be considered to insure proper interpretation of results, and the following discussion is offered as an aid to the user:

It is convenient to represent a signal source in terms of its open circuit voltage and internal impedance.* Thus a signal source or an antenna can be represented as in Figure 3. For simplicity, only the case where source and load impedance are resistive will be considered.

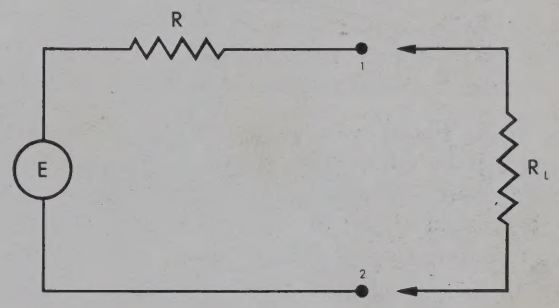


Fig. 3. Signal Source Representation

E — open circuit voltage
R — impedance looking into terminals 1 and 2
R_L — load impedance

For purposes of rating sensitivity, the input to a receiver might have been defined initially either as the open circuit source voltage E or the voltage actually across the receiver's terminals. The Institute of Radio Engineers has established the former method

**Radio Engineering, F.E. Terman, Third Edition, Page 486.*
**General Radio Experimenter, Vol. XXI, No. 1, June, 1946.*

as standard and defined receiver input in terms of the open circuit voltage of the source.**

The impedance of the signal source employed to test receivers should be equal to the impedance of the antenna with which the receiver is designed to operate. Note that in this case the voltage actually across the receiver terminal is $\frac{E}{2}$ (Receiver input impedance equal to source impedance.)

4. *Accessories* for physically connecting the instrument to the load are described in the following:

a. 505-A, 6db Pad

This pad is used as a dummy antenna in testing unbalanced receivers with a 53-ohm input as shown in Figure 4.

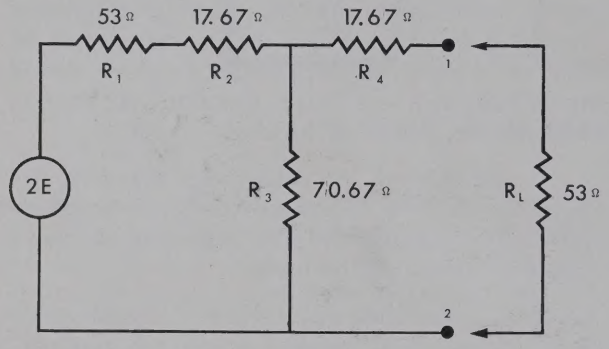


Fig. 4. 505-A T-Pad as Dummy Antenna for Receiver

E — 202 attenuator dial reading
R_1 — internal resistance of Univerter
R_2 — pad resistance
R_3 — pad resistance
R_4 — pad resistance
R_L — load impedance

The open circuit voltage appearing across terminals 1 and 2 is by Ohms law (equation 1) equal to E, half of the source voltage. Applying Thevinin's theorem the equivalent circuit of Figure 5 is obtained, and thus the attenuator dial of the 202 reads receiver sensitivity directly for the assumed standard output.

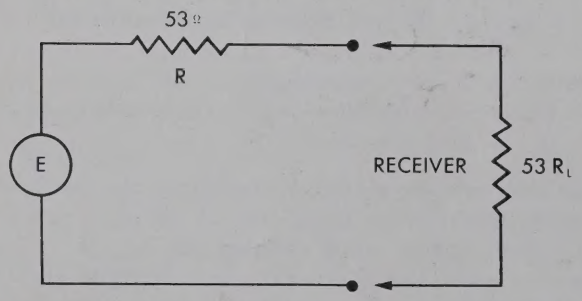


Fig. 5. Equivalent Circuit of a 505-A T-Pad as an Antenna

b. 509-A 20 db T-Pad

This pad is useful where signal levels are required which are low compared to the constant noise level of the 207. Since the noise level of the 207 is constant, the signal to noise ratio varies directly as the signal level. Therefore, with low output voltage the signal to noise ratio may be improved by increasing the input voltage and attenuating the output. For practical purposes the 20 db pad is useful at output levels below 5,000 microvolts for the 202-C and 500 microvolts for the 202-B. The signal applied to a 53-ohm load may be found by dividing the 202 attenuator dial reading by ten.

The 509-A pad, like the 505-A, may be used as a dummy antenna except that the measure of receiver sensitivity (equivalent source voltage) is one-fifth the 202 attenuator dial reading.

c. 501-A Output Cable

A 501-A Cable attached to the Univerter is illustrated by Figure 6a, where R_2 is the 53 ohm termination of the 501-A cable. The equivalent circuit (Figure 6b) is readily determined by applying Thevinin's theorem. This arrangement is recommended for general use where it is desirable to connect the Univerter output to an input circuit of relatively higher impedance than 26 ohms. The attenuator of the 202 will read the Univerter output directly.

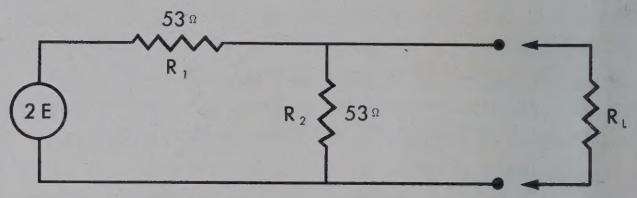


Fig. 6a. Output Circuit of 207-A with 501-A Output Cable Attached

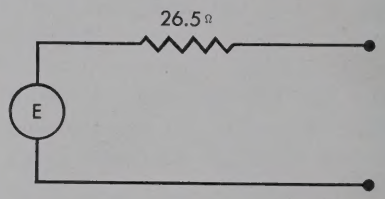


Fig. 6b. Equivalent Output Circuit of 207-A with 501A Output Cable Attached

E — 202 attenuator dial reading
R_1 — 207 internal resistance
R_2 — 501-A cable termination
R_L — load impedance

**The Institute of Radio Engineers, Section 4.01.01, 1947, Standards on Radio Receivers, The Institute of Radio Engineers, Section 4.01.01, 1948, Standards on Television.*

IV. SPECIFICATIONS.

A. RF RANGE.

Over a range of 0.1 mc. to 55 mc., with no carrier deviation, the gain of the Univerter when used in combination with the 202-B or 202-C Signal Generator is constant at unity to within ±1 db.

B. FREQUENCY INCREMENT DIAL.

This dial is calibrated in 5-kc divisions over a range of ±300 kc.

C. RF OUTPUT.

The RF output voltage across a 53 ohm load connected to the X1 OUTPUT jack is continuously variable from 0.1 microvolt to 0.1 volt by means of the 202-B or -C FM Signal Generator attenuator. At 0.2 volt input, the output is approximately 0.18 volt.

The impedance at the X1 OUTPUT jack, looking into the instrument terminal is approximately 53 ohms.

The RF output voltage at the HIGH OUTPUT jack is uncalibrated but may be controlled from the attenuator of the 202 FM-AM Signal Generator to give a maximum of about 1.5 volts. At this jack the internal impedance is approximately 330 ohms.

D. DISTORTION.

1. FM. The Univerter introduces no appreciable distortion when a frequency modulated voltage is applied from the 202-B Signal Generator.

2. AM. At carrier levels below 0.05 volts the Univerter adds no distortion to a 50% AM modulated signal. Above this level some rounding of the outward modulation peaks may occur.

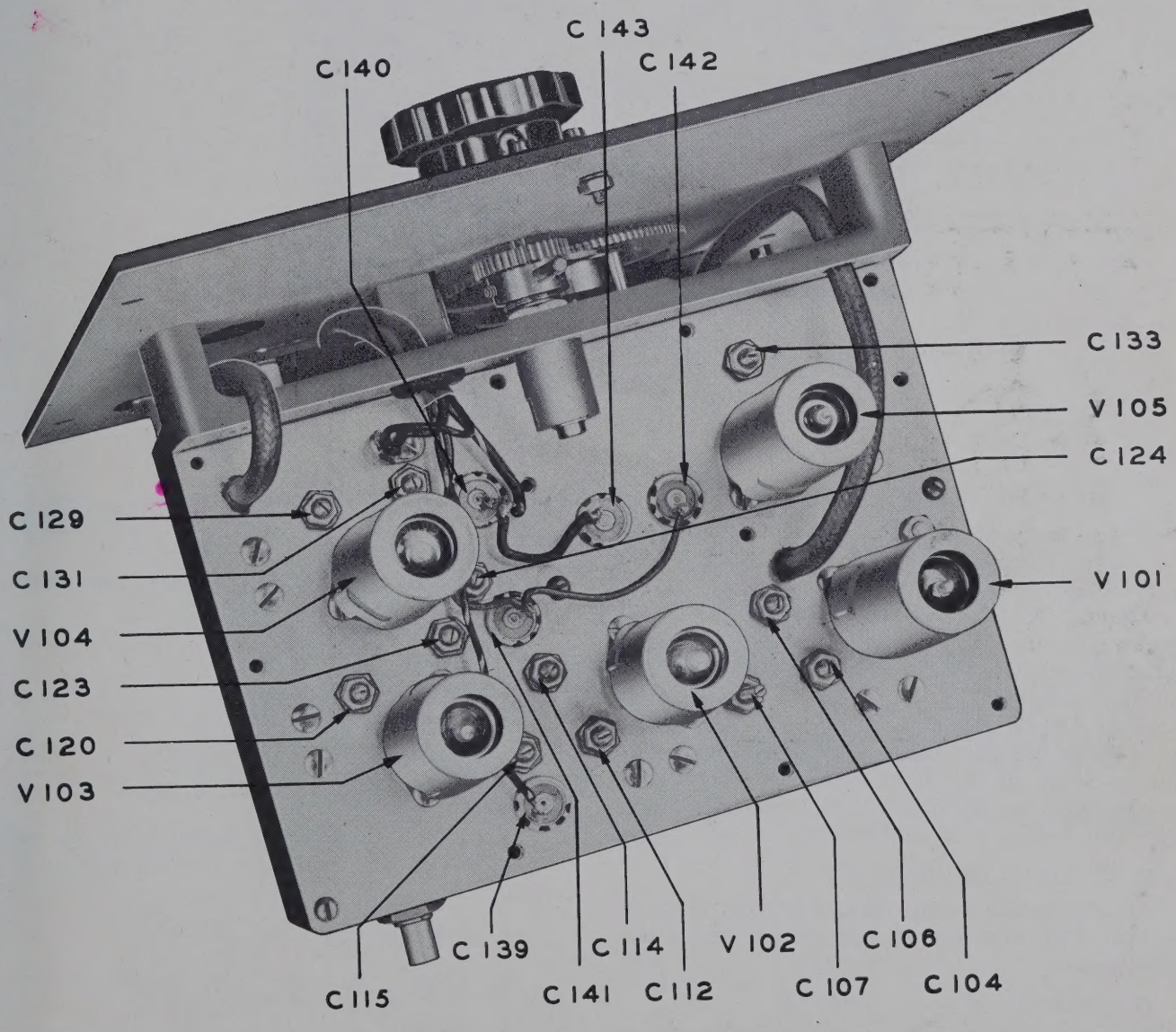


Fig. 7. Top View of 207-A Panel and RF Chassis

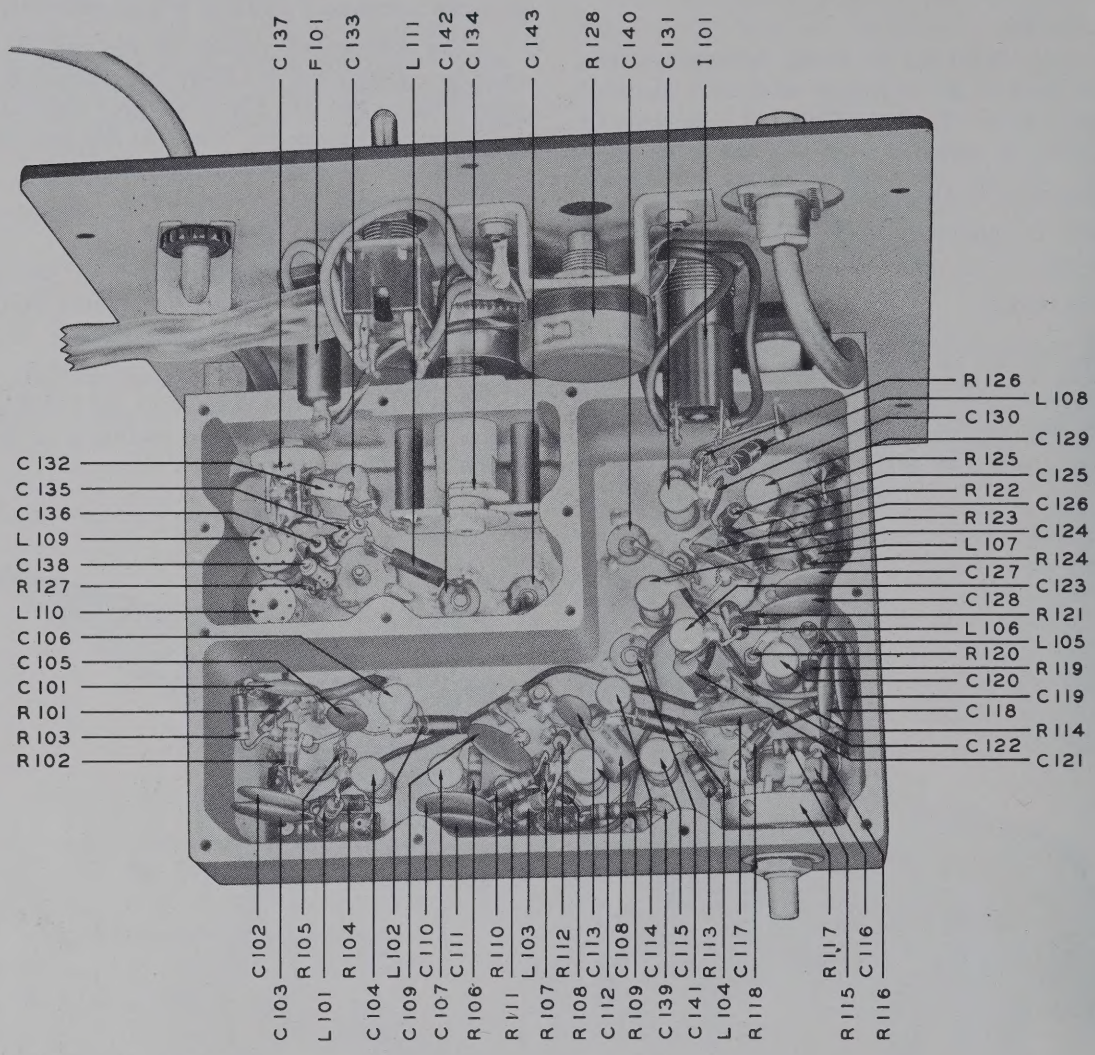


Fig. 8. Bottom View of 207-A Panel and Open RF Chassis

E. LEAKAGE.

The RF unit is completely shielded, being enclosed within an aluminum casting having silver plated brass cover plates screwed firmly in place. The oscillator section is well shielded from the remainder of the RF unit by aluminum walls within the main casting. This use of shielding reduces leakage to a low value. Leakage of the fundamental frequency is a maximum at 55 mc and occurs at the HIGH OUTPUT plug. This leakage is 50 db below the desired signal.

F. SPURIOUS RF OUTPUT.

All spurious RF output voltages at input levels of less than 0.05 volts are at least 30 db below the desired signal.

G. NOISE.

FM hum modulation is more than 80 db below 10 kc deviation.

Random noise is 4 μv over a 20 kc band width.

H. TUBE COMPLEMENT.

Oscillator - 6C4 (V-105)
Mixer - 6AB4 (V-101)
RF Amplifier - 6AK5 (V-102, V-103)
Output Stage - 6AH6 (V-104)

I. POWER SUPPLY.

The 207-A Univerter is designed for use on 60 cycles, 90-130 volts, with a power consumption of 45 watts.

J. DIMENSIONS.

H: 11½" W: 7⅜" D: 10½"

K. WEIGHT.

20 pounds.

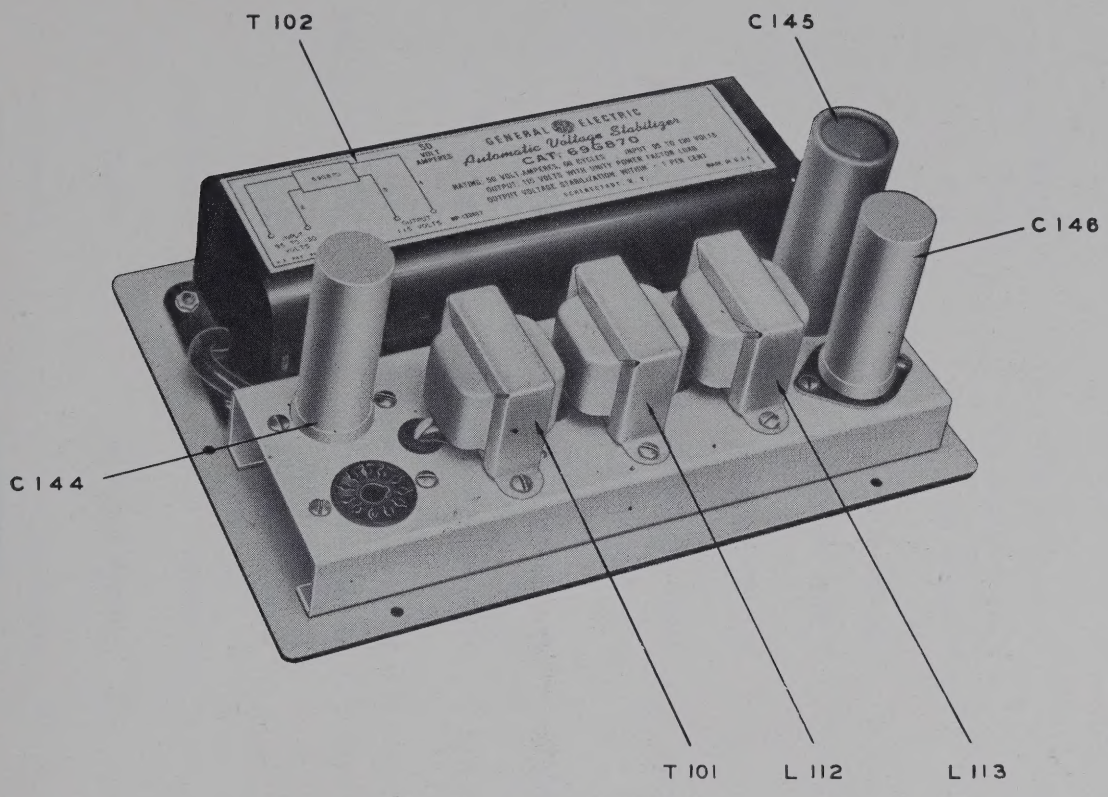


Fig. 9. Top View of 207-A Power Supply

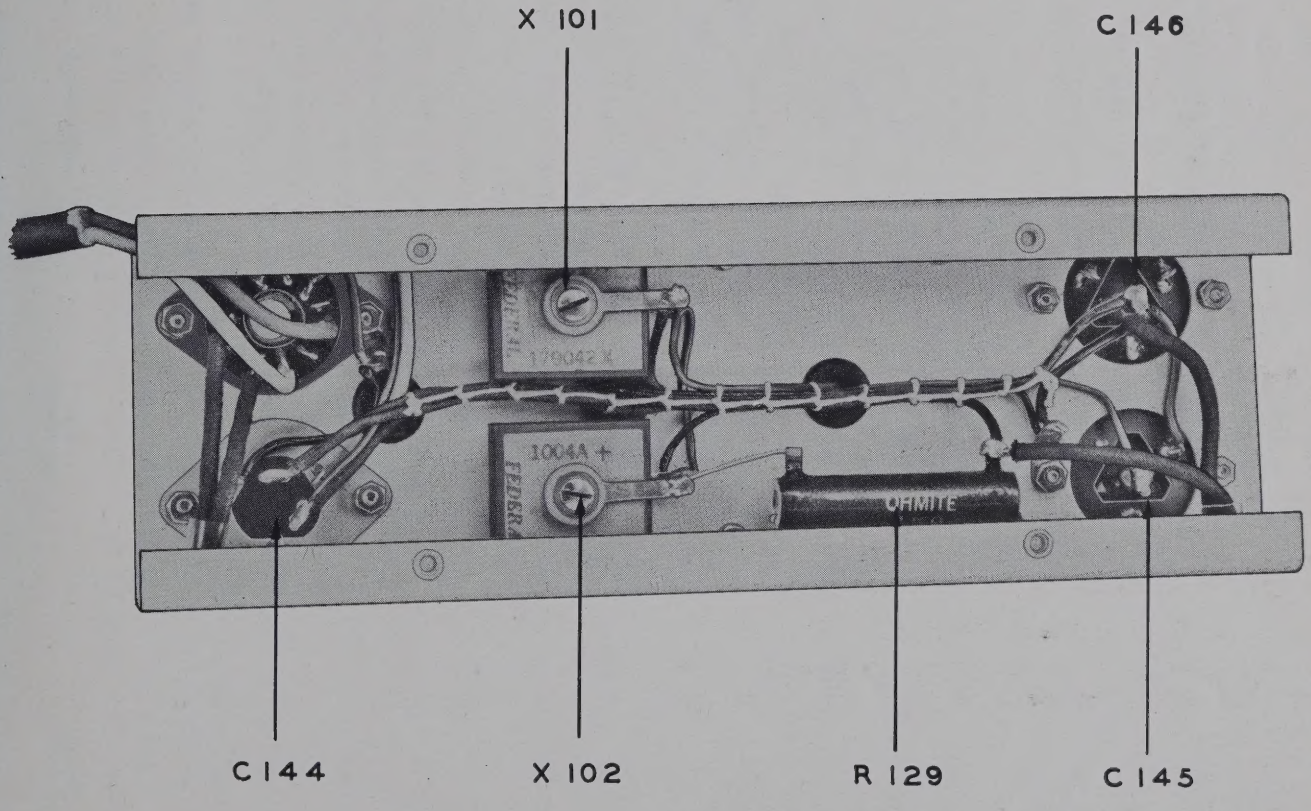


Fig. 10. Bottom View of 207-A Supply

MAINTENANCE PARTS LIST FOR TYPE CA-207-A FREQUENCY UNIVERTER

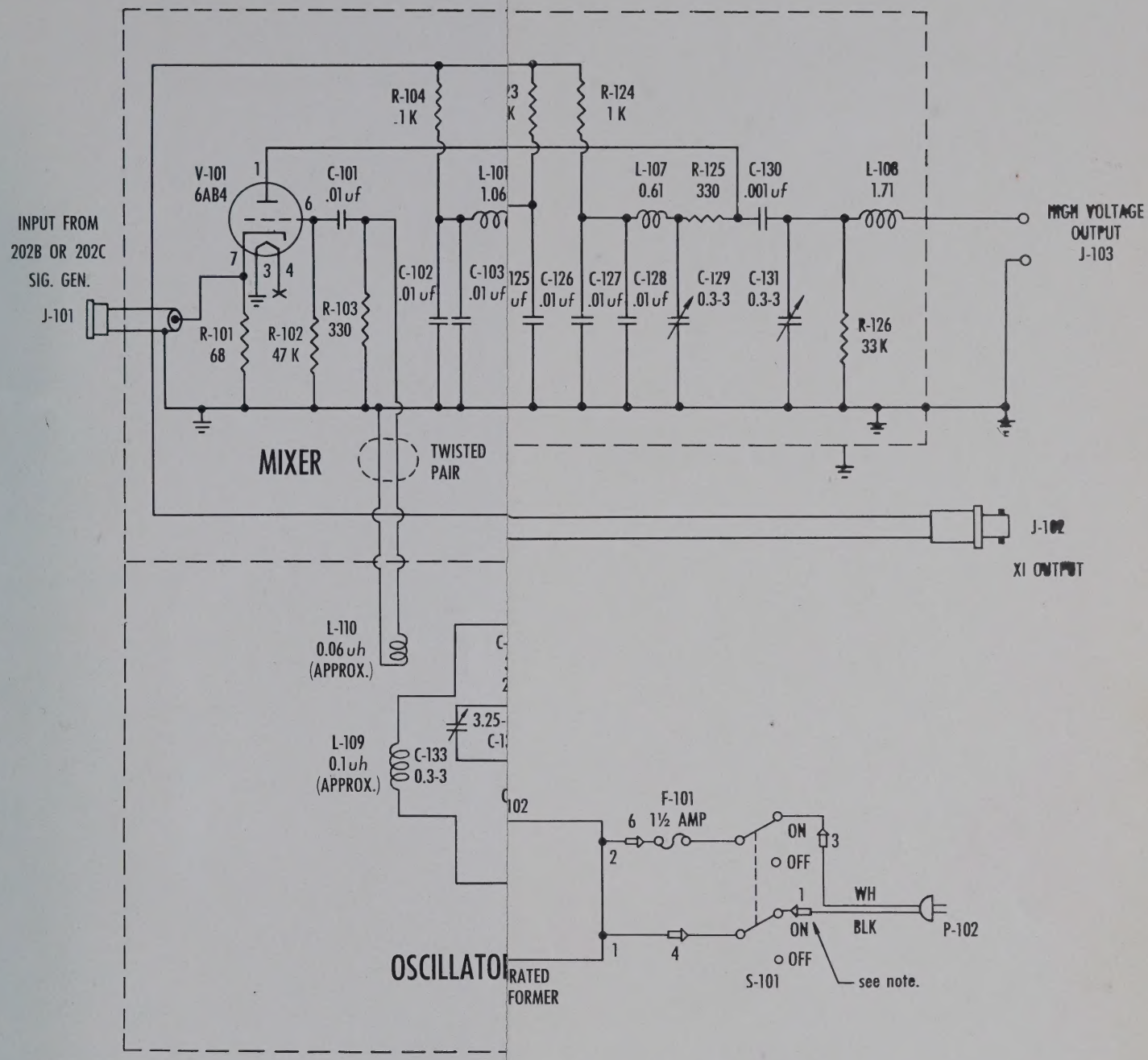
Reference Symbol	Boonraco No.	Description	Manufacturer	Manufacturer's Designation
C-101, 2, 3, 9, 10, 11, 17, 18, 19, 26, 27, 28	82428	CAPACITOR, .01 μf, +80% —20%, 600 V, ceramic disc.	Centralab	DA048-003A
C-104, 6, 7, 12, 14, 15, 20, 23, 24, 29, 31, 33	84000	CAPACITOR, .3-3 μμf, 1500V, pyrex	Corning Glass Co.	690082
C-105, 13, 22, 30	82306	CAPACITOR, 1000 μμf, +80% —20%, 600 V, ceramic disc.	Centralab	DA140-002A
C-108, 16, 25	83019	CAPACITOR, .1 μf, +30% —20%, 200V, metallized paper.	Astron Corp.	ML-2-1
C-121	82032	CAPACITOR, 5 μμf, ±5%, 500V, ceramic	Erie Resistor Corp.	JAN-CC21CKO50C
C-132	82108	CAPACITOR, 39 μμf, ±2%, 500V, N150, ceramic	Electrical Reactance Co.	CN-1
C-135	82013	CAPACITOR, 15 μμf, ±2%, 500V, N150, ceramic	Electrical Reactance Co.	CN-1
C-136	82023	CAPACITOR, 15 μμf, ±2%, 500V, NPO, ceramic	Electrical Reactance Co.	CN-1
C-137	84011	CAPACITOR, 1.7-3.3 μμf, 1.7-3.3 μμf.	E. F. Johnson & Co.	3MB11
C-138	82003	CAPACITOR, 5 μμf, ±5%, 500V, NPO, ceramic	Electrical Reactance Co.	CN-1
C-139, 40, 41, 42, 43, 47	82307	CAPACITOR, .001 μf, ±10%, 500V, silver-mica, button	Erie Resistor Corp.	370-BB
C-144, 46	83094	CAPACITOR, 40 μf-40μf, 200V, electrolytic	Sprague Specialties Co.	ELS-9
C-145	83093	CAPACITOR, 40 μf-40 μf, 200V, electrolytic, inslaution sleeve	Sprague Specialties Co.	ELS-9
F-101	93250	FUSE, 1½ a	Littlefuse Inc.	3AG-1½
I-101	90904	LAMP, Incandescent, 6.3V, 0.15a	General Electric Co.	47
J-101	94156	CONNECTOR, Plug, one round male contact	Industrial Products Co.	UG-88/U
J-102	89065	CONNECTOR, Receptacle, one round female contact	Industrial Products Co.	UG-291/U
J-103	300286	SOCKET, Crystal	James Millen Mfg. Co. Inc.	K-33102
L-101, 3	300326	CHOKE, 1.06 μh, ±3%	Boonton Radio Corp.	300326

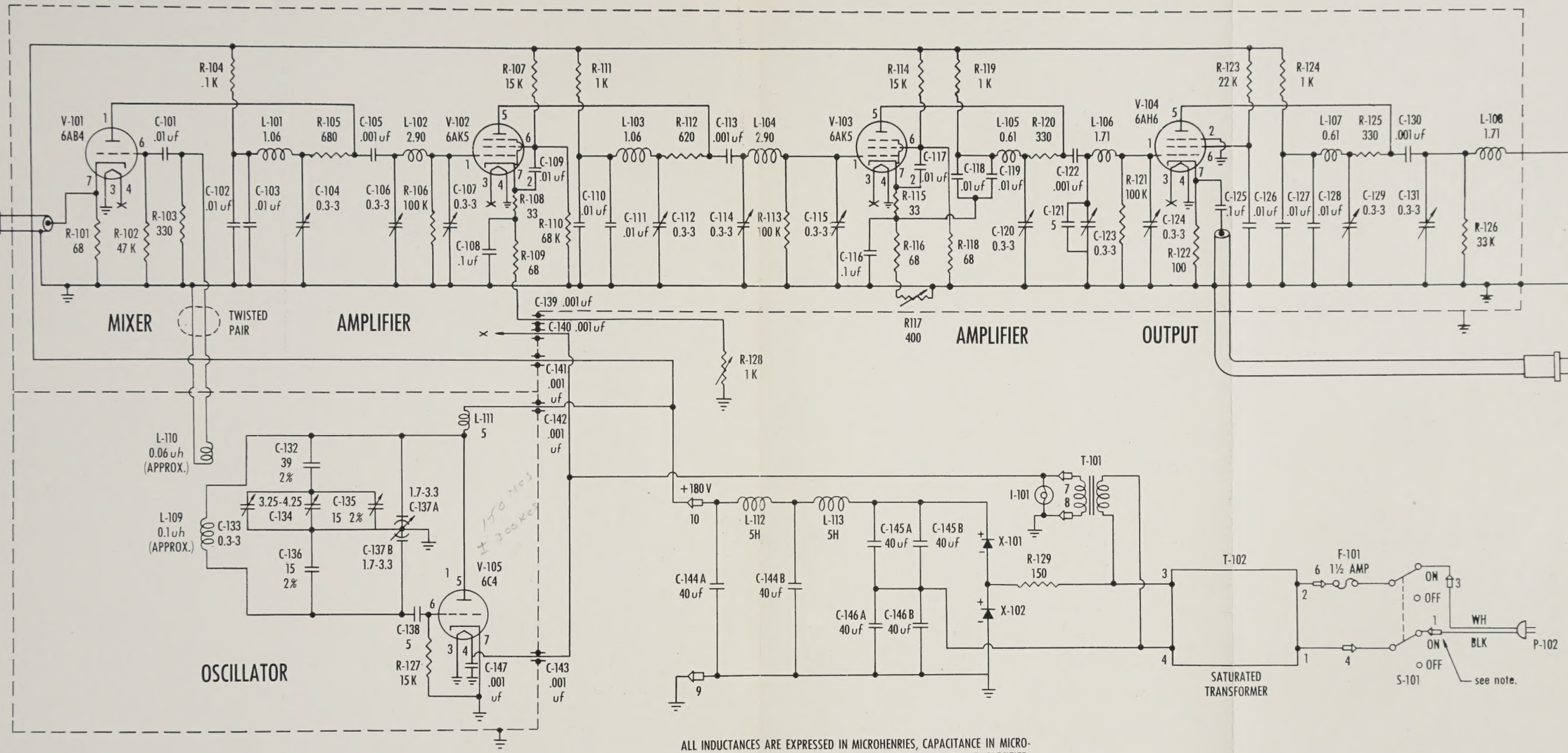
MAINTENANCE PARTS LIST FOR TYPE CA-207-A FREQUENCY UNIVERTER—*(Continued)*

Reference Symbol	Boonraco No.	Description	Manufacturer	Manufacturer's Designation
L-102, 4	300325	CHOKE, 2.90 μh, ±3%	Boonton Radio Corp.	300325
L-105-7	300323	CHOKE, 0.61 μh, ±3%	Boonton Radio Corp.	300323
L-106, 8	300322	CHOKE, 1.71 μh, ±3%	Boonton Radio Corp.	300322
L-109	300328	COIL, Oscillator, 0.1 μh	Boonton Radio Corp.	300328
L-110	300329	COIL, Pick-up, 0.06 μh	Boonton Radio Corp.	300329
L-111	300327	CHOKE, 5 μh, ±5%	Boonton Radio Corp.	300327
L-112, 13	85412	CHOKE, Filter, 5h at 75 ma	Freed Transformer Co.	F614-A
P-101	94149	CONNECTOR, Plug. eleven round male contacts	American Phenolic Corp.	PM-11-11
R-101, 9, 16	80057	RESISTOR, 68 ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-102	80460	RESISTOR, 47K ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-103, 20, 25	80172	RESISTOR, 330 ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-104, 11, 19, 24	80148	RESISTOR, 1K ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-105	80138	RESISTOR, 680 ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-106, 13, 21	80517	RESISTOR, 100K ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-107, 14, 27	80336	RESISTOR, 15K ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-108, 15	80032	RESISTOR, 33 ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-110, 18	80549	RESISTOR, 68K ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-112	80191	RESISTOR, 620 ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-117	81116	POTENTIOMETER, 400 ohms, 2W	P. R. Mallory & Co. Inc.	C-400P
R-122	80062	RESISTOR, 100 ohms, ±5%, ½	Allen-Bradley Co.	EB
R-123	80472	RESISTOR, 22K ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-126	80461	RESISTOR, 33K ohms, ±5%, ½W	Allen-Bradley Co.	EB
R-128	81119	POTENTIOMETER, 1K ohms, 2W	Allen-Bradley Co.	JLU-1021
R-129	80090	RESISTOR, 150 ohms, ±5%, 20W	Electrohm Inc.	2R
S-101	88059	SWITCH, Toggle DPDT	Arrow-Hart & Hegeman Electric Co.	82305B
T-101	85003	TRANSFORMER, Filament	Freed Transformer Co.	F-128

MAINTENANCE PARTS LIST FOR TYPE CA-207-A FREQUENCY UNIVERTER—*(Continued)*

Reference Symbol	Boonraco No.	Description	Manufacturer	Manufacturer's Designation
T-102	85028	STABILIZER, Constant Voltage	General Electric Co.	69G870
V-101		TUBE, 6AB4		
V-102, 3		TUBE, 6AK5		
V-104		TUBE, 6AH6		
V-105		TUBE, 6C4		
X-101, 2	300316	RECTIFIER, Selenium, 100 ma	Federal Telephone & Radio Co.	403D2625A
	89022	INDICATOR, Light, miniature bayonet	Dial Light Co.	BV-844S
	89027	SOCKET, Tube, 7 contact miniature (5 req'd.)	Hugh H. Eby Co.	102-M
	89067	SOCKET, Tube, 11 contact	American Phenolic Corp.	MIP-11
	89075	SHIELD, Tube (3 req'd.)	Hugh H. Eby Co.	7798
	89088	SHIELD, Tube (2 req'd.)	Hugh H. Eby Co.	7797
	89102	CONNECTOR, Receptacle, recessed, two male contacts	General Electric Co.	2711
	93667	HOLDER, Fuse, extractor post	Bussmann Mfg. Co.	MTH-6
	300729	CORD, Power, separable	Boonton Radio Corp.	300729


R-104
.1 K
R-124
1 K
V-101
6AB4
C-101
.01 uf
L-101
1.06
L-107
0.61
R-125
330
C-130
.001 uf
L-108
1.71
INPUT FROM
202B OR 202C
SIG. GEN.
J-101
HIGH VOLTAGE
OUTPUT
J-103
C-102
.01 uf
C-103
.01 uf
C-126
.01 uf
C-127
.01 uf
C-128
.01 uf
C-129
0.3-3
C-131
0.3-3
R-101
68
R-102
47 K
R-103
330
R-126
33 K
MIXER
TWISTED
PAIR
J-102
XI OUTPUT
L-110
0.06 uh
(APPROX.)
L-109
0.1 uh
(APPROX.)
C-133
0.3-3
F-101
6 1½ AMP
ON
OFF
WH
BLK
P-102
S-101
see note.
OSCILLATOR
RATED
FORMER



ALL INDUCTANCES ARE EXPRESSED IN MICROHENRIES, CAPACITANCE IN MICRO-MICROFARADS, AND RESISTANCE IN OHMS UNLESS OTHERWISE SPECIFIED.

"K"=1,000; "M"=1,000,000

➔ POWER SUPPLY CHASSIS PLUG P-101
POINT OF SYMBOL INDICATES DIRECTION OF WIRE COMING FROM PLUG PRONG INTO CABLE.

Fig. 11. Schematic Wiring Diagram of 207-A Univerter